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| Name: | | Start Date: | | | | | | 11/29/16 |  |  |
|  | | Quest 4 Date: | | | | | | 12/15/16 (Gamma) 12/16/16 (Epsilon) |  |  |
| Period: (Honors) | | Teacher: Ms. J | | | | | | |  |  |
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| **Cells & Cell Processes** | | Submitted | Resubmit | | Correct | | Evidence of Learning | | Page | Date |
| **Objective 9:** Analyze how cells grow and reproduce in terms of interphase, mitosis, and cytokinesis. | |  |  | |  | | Notes: Why Cells Divide | |  |  |
|  |  | |  | | Article: “Your Body Is Younger Than You Think” | |  |  |
|  |  | |  | | Catalyst 1 | |  |  |
|  |  | |  | | Lab: Surface Area Cut-Out | |  |  |
|  |  | |  | | Catalyst 2 | |  |  |
|  |  | |  | | Notes: Mitosis & Cancer | |  |  |
|  |  | |  | | HW: Video Questions | |  |  |
|  |  | |  | | Lab: Mitosis Cut & Paste | |  |  |
|  |  | |  | | HW: Mitosis Practice | |  |  |
|  |  | |  | | Lab: Mitosis Length of Phases | |  |  |
|  |  | |  | | Article: Cancer | |  |  |

**Unit 2: Cells & Cell Processes**

Start Date: 11/28/16 Test 4 Date: 01/09/17

**Objective 9:**  Analyze how cells grow and reproduce in terms of interphase, mitosis, and cytokinesis.

*Essential Question:* What is the cell cycle?

*Essential Question:* What is the sequence and function of mitosis?

*“I Can” Statements:*

* Describe/outline the stages of the Cell Cycle: Growth 1, Synthesis, Growth 2, Mitosis, and Cytokinesis
* Organize diagrams of mitotic phases and describe what is occurring throughout the process

**Objective 10:** Explain how genetic and environmental factors can influence the cell cycle and lead to cancer.

*Essential Question:*  What is cancer?

*Essential Questions:* What causes cancer?

*Essential Questions:* How are different cancers caused, treated, and prevented?

*“I Can” Statements:*

* Describe the relationship between mutations in the DNA and uncontrolled cell growth
* Use an example of a specific cancer to illustrate how cancer is caused, treated and prevented

**Objective 11:** Explain how instructions in DNA lead to cell differentiation and result in cells specialized to perform specific functions in multicellular organisms.

*Essential Question:* How do cells become specialized?

*“I Can” Statements:*

* Explain that cells differentiate and give examples of differentiation/specialization
* Describe stem cells as undifferentiated and discuss how this is important to scientific research
* Explain the relationship between DNA expression and the type of cell that develops through differentiation

**Catalyst 1:**

**Catalyst 2:**

Biology I (Honors) Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Notes: Why Cells Divide Period: \_\_\_\_ Date: \_\_\_/\_\_\_/\_\_\_

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Biology I (Honors) Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Article: Your Body Is Younger Than You Think Period: \_\_\_\_ Date: \_\_\_/\_\_\_/\_\_\_

***Your Body Is Younger Than You Think***

**By**[**NICHOLAS WADE**](http://www.nytimes.com/by/nicholas-wade) AUG. 2, 2005

Whatever your age, your body is many years younger. In fact, even if you're middle aged, most of you may be just 10 years old or less.

This heartening truth, which arises from the fact that most of the body's tissues are under constant renewal, has been underlined by a novel method of estimating the age of human cells. Its inventor, Jonas Frisen, believes the average age of all the cells in an adult's body may turn out to be as young as 7 to 10 years.

But Dr. Frisen, a stem cell biologist at the Karolinska Institute in Stockholm, has also discovered a fact that explains why people behave their birth age, not the physical age of their cells: a few of the body's cell types endure from birth to death without renewal, and this special minority includes some or all of the cells of the cerebral cortex.

It was a dispute over whether the cortex ever makes any new cells that got Dr. Frisen looking for a new way of figuring out how old human cells really are. Existing techniques depend on tagging DNA with chemicals but are far from perfect. Wondering if some natural tag might already be in place, Dr. Frisen recalled that the nuclear weapons tested above ground until 1963 had injected a pulse of radioactive carbon-14 into the atmosphere.

Breathed in by plants worldwide and eaten by animals and people, the carbon-14 gets incorporated into the DNA of cells each time the cell divides and the DNA is duplicated.

Most molecules in a cell are constantly being replaced but the DNA is not. All the carbon-14 in a cell's DNA is acquired on the cell's birth date, the day its parent cell divided. Hence the extent of carbon-14 enrichment could be used to figure out the cell's age, Dr. Frisen surmised. In practice, the method has to be performed on tissues, not individual cells, because not enough carbon-14 gets into any single cell to signal its age. Dr. Frisen then worked out a scale for converting carbon-14 enrichment into calendar dates by measuring the carbon-14 incorporated into individual tree rings in Swedish pine trees.

Having validated the method with various tests, he and his colleagues have reported in the July 15 issue of Cell the results of their first tests with a few body tissues. Cells from the muscles of the ribs, taken from people in their late 30's, have an average age of 15.1 years, they say.

The epithelial cells that line the surface of the gut have a rough life and are known by other methods to last only five days. Ignoring these surface cells, the average age of those in the main body of the gut is 15.9 years, Dr. Frisen found.

The Karolinska team then turned to the brain, the renewal of whose cells has been a matter of much contention. Prevailing belief, by and large, is that the brain does not generate new neurons after its structure is complete, except in two specific regions, the olfactory bulb that mediates the sense of smell, and the hippocampus where initial memories of faces and places are laid down.

This consensus view was challenged a few years ago by Elizabeth Gould of Princeton, who reported finding new neurons in the cerebral cortex, along with the elegant idea that each day's memories might be recorded in the neurons generated that day.

Dr. Frisen's method will enable all regions of the brain to be dated to see if any new neurons are generated. So far he has tested only cells from the visual cortex. He finds these are exactly the same age as the individual, showing that new neurons are not generated after birth in this region of the cerebral cortex, or at least not in significant numbers. Cells of the cerebellum are slightly younger than those of the cortex, which fits with the idea that the cerebellum continues developing after birth.

Another contentious issue is whether the heart generates new muscle cells after birth. The conventional view that it does not has recently been challenged by Dr. Piero Anversa of the New York Medical College in Valhalla. Dr. Frisen has found the heart as a whole is generating new cells but he has not yet measured the turnover rate of the heart's muscle cells.

Although people may think of their body as a fairly permanent structure, most of it is in a state of constant flux as old cells are discarded and new ones generated in their place. Each kind of tissue has its own turnover time, depending in part on the workload endured by its cells. The cells lining the stomach, as mentioned, last only five days. The red blood cells, bruised and battered after traveling nearly 1,000 miles through the maze of the body's circulatory system, last only 120 days or so on average before being dispatched to their graveyard in the spleen.

The epidermis, or surface layer of the skin, is recycled every two weeks or so. The reason for the quick replacement is that "This is the body's saran wrap, and it can be easily damaged by scratching, solvents, wear and tear," says Elaine Fuchs, an expert on the skin's stem cells at Rockefeller University.

As for the liver, the detoxifier of all the natural plant poisons and drugs that pass a person's lips, its life on the chemical warfare front is quite short. An adult human liver probably has a turnover time of 300 to 500 days, says Markus Grompe, an expert on the liver's stem cells at the Oregon Health & Science University.

Other tissues have lifetimes measured in years, not days, but are still far from permanent. Even the bones endure nonstop makeover. The entire human skeleton is thought to be replaced every 10 years or so in adults, as twin construction crews of bone-dissolving and bone-rebuilding cells combine to remodel it.

About the only pieces of the body that last a lifetime, on present evidence, seem to be the neurons of the cerebral cortex, the inner lens cells of the eye and perhaps the muscle cells of the heart. The inner lens cells form in the embryo and then lapse into such inertness for the rest of their owner's lifetime that they dispense altogether with their nucleus and other cellular organelles.

But if the body remains so perpetually youthful and vigorous, and so eminently capable of renewing its tissues, why doesn't the regeneration continue forever?

Some experts believe the root cause is that the DNA accumulates mutations and its information is gradually degraded. Others blame the DNA of the mitochondria, which lack the repair mechanisms available for the chromosomes. A third theory is that the stem cells that are the source of new cells in each tissue eventually grow feeble with age.

"The notion that stem cells themselves age and become less capable of generating progeny is gaining increasing support," Dr. Frisen said. He hopes to see if the rate of a tissue's regeneration slows as a person ages, which might point to the stem cells as being what one unwetted heel was to Achilles, the single impediment to immortality.

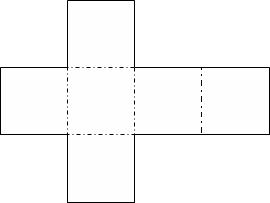
Biology I (Honors) Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Lab: Surface Area Cut-Out Period: \_\_\_\_ Date: \_\_\_/\_\_\_/\_\_\_

**Objective 9:** Analyze how cells grow and reproduce in terms of interphase, mitosis, and cytokinesis.

### Part One – Paper Simulation

One reason that cells are small is that, as they grow, their volume increases at a different rate than their surface area. In this lab, you will measure the difference in the increases of volume and surface area.

**Procedure:**

1. Cut out the two cubes from the attached piece of paper. *Cut along solid lines only!* Assume that the first cube measures 1cm on each side and that the large cube measures 2cm on each side.
2. Put together each cube – use tape to secure the flaps.
3. Calculate the area of one side of each cube. Record in the data table below. (Area = length x width)
4. Calculate the surface area of each cube by multiplying the area of one side by six. Record in the data table below.
5. Calculate the volume of each cube. Record in the data table below. (Volume = length x width x height)

**Data:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Cube** | **Area of one side**  **(length x width)** | **Surface Area**  **(length x width x 6)** | **Volume**  **(length x width x height)** |
| 1 cm on each side |  |  |  |
| 2 cm on each side |  |  |  |

### Part Two – Cell Size

Cell size is usually expressed in micrometers – μm. A micrometer is 1000 times smaller than a millimeter. As cells grow, the ratio between their surface area and their volume changes. We will use cubes to simulate the changes a cell goes through as it grows.

**Procedure:**

1. Start with the cube that measures 1 μm on each side.
   1. Calculate its surface area. (Surface area = length x width x 6).
   2. Calculate its volume. (Volume = length x width x height).
2. Suppose this cube grows so that each side measures 2 μm. Calculate its surface area and volume.
3. Calculate the surface area and volume for each of the cubes listed.
4. Use your data to complete the graph that follows.

**Data:**

|  |  |  |
| --- | --- | --- |
| **Length of one side** | **Surface Area, μm2**  **(length x width x 6)** | **Volume, μm3**  **(length x width x height)** |
| 1 μm |  |  |
| 2 μm |  |  |
| 3 μm |  |  |
| 4 μm |  |  |
| 5 μm |  |  |
| 6 μm |  |  |
| 7 μm |  |  |
| 8 μm |  |  |

**Graph:**

1. Give your graph a title. We will be graphing surface area vs. volume.
2. Number the x-axis. These numbers will come from the first column of the table.
3. Number the y-axis. These numbers will come from the second and third columns of the table.
4. Plot the points corresponding to the length of one side (x-axis) and the surface area (y-axis).
   1. Draw a line to connect these points.
   2. Label the line “surface area”.
5. Plot the points corresponding to the length of one side (x-axis) and the volume (y-axis).
   1. Draw a line to connect these points.
   2. Label the line “volume”.

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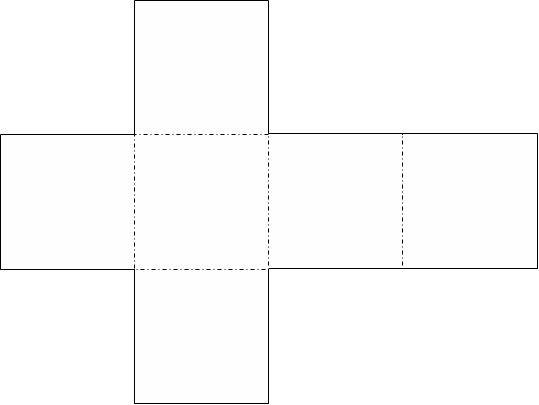
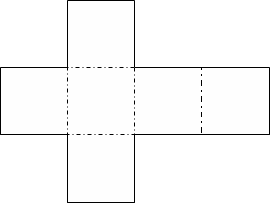
Surface Area (μm2)

Volume (μm3)

Length of one side (μm)

**Analysis:**

1. If a cell were to increase in size from 1 to 2 cm per side, how many *times* larger would its volume be? (Look at the table on the front) \_\_\_\_\_\_\_\_\_\_\_
2. If a cell were to increase in size from 1 to 2 cm per side, how many *times* larger would its surface area be? (Look at the table on the front) \_\_\_\_\_\_\_\_
3. Which increases more quickly – the surface area or the volume? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
4. What is the significance of this for cell size?
5. How many 1-cm cubes would it take to assemble a cube as large as your 2-cm cube? \_\_\_\_\_\_\_\_\_
6. What would be the ***total*** surface area of the 1-cm cubes used to assemble a 2-cm cube? \_\_\_\_\_\_\_\_\_  
   (Surface area of 1 cube x the number of cubes it would take to fill the 2-cm cube.)
7. Using information from these laboratory activities, write a paragraph that *explains why cells must divide*.



Biology I (Honors) Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Notes: Mitosis & Cancer Period: \_\_\_\_ Date: \_\_\_/\_\_\_/\_\_\_

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Biology I (Honors) Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Homework: Mitosis Video Questions Period: \_\_\_\_ Date: \_\_\_/\_\_\_/\_\_\_

**Directions: Go to the link below and watch the Mitosis animation video. As you watch, answer the questions below.**

http://vcell.ndsu.nodak.edu/animations/mitosis/movie-flash.htm

1. Why is cell division necessary?

2. Define mitosis.

3. What is the first phase of mitosis and what are 2 key events that happen in that stage?

4. What happens in metaphase? What happens in Anaphase?

5. Mitosis is completed after telophase. What happens to the DNA in telophase?

6. What happens after mitosis?

7. How often are eukaryotic cells duplicated?

8. What is the longest phase of the cell cycle?

9. What happens in the following phases:

G1-

S-

G2-

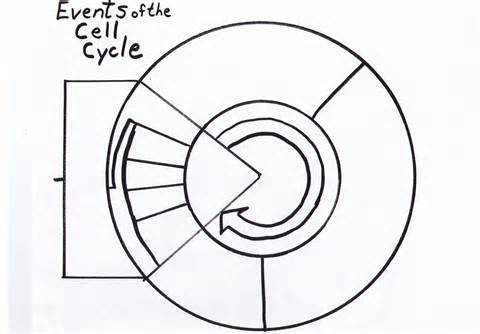
10. How long does it take a cell to complete mitosis?

11. What happens to the nucleolus during prophase?

12. How does each new daughter cell get their organelles?

Label following diagram of the cell cycle using the following terms:

* Mitosis
* G1 phase
* S phase
* G2 phase
* Prophase
* Telophase
* Cytokinesis
* Anaphase
* Metaphase
* Cell Division
* Interphase



Biology I (Honors) Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Lab: Mitosis Cut & Paste Period: \_\_\_\_ Date: \_\_\_/\_\_\_/\_\_\_

**Objective 9:** Analyze how cells grow and reproduce in terms of interphase, mitosis, and cytokinesis.

**Purpose:**

In this lab, you will demonstrate your understanding of the cell cycle and mitosis by using the chromosomes on the attached page to model various stages of the cell cycle. You will correctly sequence the stages and be able to identify what happens at each stage of the cell cycle.

**Materials:** Colored pencils (3) Glue Scissors

**Procedure:**

1. Using 2 different colors, color the chromosomes. Each homologous pair should be the same color   
   [e.g., all the 1’s should be green (1a & 1b)]
2. The first stage of the cell cycle is interphase, which is broken into three parts. What happens in each of these three parts?
   1. G1: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
   2. S: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
   3. G2: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. Cut out the chromosomes.
4. Arrange the 4 chromosomes in the boxes below as they would appear during each phase of mitosis.   
   Draw any of the following structures that would be found: cell membrane, nucleus, centrioles, spindle fibers, nuclear envelope.   
   Describe the important parts of each phase.

|  |  |
| --- | --- |
| **Prophase** | Events:  1.  2.  3. |

|  |  |
| --- | --- |
| **Metaphase** | Events:  1.    2.  3. |
| **Anaphase** | Events:  1.  2.  3. |
| **Telophase** | Events:  1.  2. |

1. After telophase is complete, the cell undergoes cytokinesis. What happens in the cell during cytokinesis?   
   \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

|  |  |  |
| --- | --- | --- |
|  |  | (Extra) |
|  |  | (Extra) |

|  |  |  |
| --- | --- | --- |
|  |  | (Extra) |
|  |  | (Extra) |
|  |  |  |
|  |  | (Extra) |
|  |  | (Extra) |

**MITOSIS PRACTICE**

**Matching:** Match the term to the description

I = interphase P = prophase M = metaphase A = anaphase T = telophase

\_\_\_\_\_ 1. The sister chromatids are moving apart. \_\_\_\_\_ 8. Animal cells begin to pinch in.

\_\_\_\_\_ 2. The nuclear membrane fades from view. \_\_\_\_\_9. The spindle is formed.

\_\_\_\_\_3. A new nuclear membrane is forms. \_\_\_\_\_10. Chromatids line up along the equator.

around the chromosomes

\_\_\_\_\_ 4. The cytoplasm of the cell is being divided. \_\_\_\_\_ 11. Chromosomes are not visible.

\_\_\_\_\_ 5. The chromatin is found in the nucleus. \_\_\_\_\_ 12. Cytokinesis begins.

\_\_\_\_\_ 6. The chromosomes are located at. \_\_\_\_\_ 13. The cell plate in plants **begins** to form.

the equator of the cell

\_\_\_\_\_ 7. The spindles disappear. \_\_\_\_\_ 14. The reverse of prophase.

**E.** Anaphase

**C.** Telophase

**D.** Metaphase

**A.** Prophase

**K.** Cell Plate

**I.** Mitosis

**H.** Cytokinesis

**F.** Centromere

**C.** Telophase

**.** Prophase

**E.** Anaphase

**D.** Metaphase

**F.** Centromere

**K.** Cell Plate

**I.** Mitosis

**H.** Cytokinesis

**E.** Anaphase

**C.** Telophase

**Fill in the blanks using the word bank below:**

Interphase Prophase Anaphase Telophase Metaphase

Cytokinesis (2x) Sister Chromatid Centromere Cell Plate

**G**. Sister Chromatid

**B.** Interphase

**B.** Interphase

**B.** Interphase

**B.** Interphase

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_18. In what phase does the cell begin to split the cytoplasm and daughter cells first become visible in mitosis?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_19. During what phase of mitosis do centromeres divide and the chromosomes move toward their respective poles?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_20. What is the phase where chromatin condenses to form chromosomes?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_21. What is the name of the structure that connects the two sister chromatids?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_22. In a chromosome pair connected by a centromere, what is each individual

chromosome half called?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_23. What is the step of cell division where 2 identical daughter cells are formed?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_24. Which phase of the cell cycle occurs when the cell is preparing to divide so it grows in size making organelles and copying DNA?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_25. What forms across the center of a plant cell near the end of telophase?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_26. What is the division of the cytoplasm called?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_27. During this phase chromosomes line up in the middle.

**Mitosis Worksheet**

**The diagram below shows six cells in various phases of the cell cycle. Note the cells are not arranged in the order in which mitosis occurs and one of the phases of mitosis occurs twice. Use the diagram to answer questions 1-7.**



1) Cells A and D show an early and a late stage of the same phase of mitosis. What phase is it?

2) Which cell is in metaphase?

3) Which cell is in the first phase of mitosis?

4) In cell A, what structure is labeled X?

5) Place the diagrams in order from first to last.

6) Are the cells depicted plant or animal cells? Explain your answer.

7) What is the longest phase of the entire cell cycle?

8) Why is mitosis important?

Biology I (Honors) Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Lab: How Long is Each Phase of Mitosis Period: \_\_\_\_ Date: \_\_\_/\_\_\_/\_\_\_

**Objective 9:** Analyze how cells grow and reproduce in terms of interphase, mitosis, and cytokinesis.

**Background Information**

In this investigation, you will determine if all phases of mitosis require the same amount of time for completion. This question can be answered by counting the number of onion root-tip cells in the four phases of mitosis and in interphase. Many cells in one specific phase indicate that a long period of time is required for completion of that phase. Few cells in a specific phase indicate that a short period of time is required for completion of that phase. Interphase and the four phases of mitosis together are called the *cell cycle*.

**Materials**

* Microscope
* Colored pencils
* Prepared slides of onion (*Allium*), Root Apical Meristems, longitudinal

**Procedure**

*Part A – Locating and Counting Cells in Mitosis*

1. Make a hypothesis to predict which phase of mitosis takes the longest time. Write your hypothesis in the “if… then… because…” format in the space provided.
2. Using the microscope, locate on an onion root-tip slide an area with cells undergoing the process of mitosis. This should be an area near the ***tip*** of the onion. After locating the cells under low power, switch to high power.
3. Count and record in Table 1 the number of cells in each phase of the cell cycle. Count ***all*** cells in the field of view.
4. Move the slide so that you are looking at a new area of cells. Count and record the number of cells in each phase of the cell cycle for this area.
5. Total the number of cells counted in each phase and in interphase for the three areas. Record this figure in the column marked “Total Number of Cells in Each Phase” in Table 1. Add the total number of cells viewed in each phase and interphase to get the total of all cells counted. Record this number in Table 1.

*Part B – Determining the Time Required for Each Phase*

Assume that the number of cells in a phase is an indication of the time spent in that phase during mitosis. Time spent in a mitosis phase and in interphase can be calculated if the total time for mitosis is known. Onion cells require 12 hours (720 minutes) to complete a cell cycle (from interphase to interphase). The amount of time needed for a phase can be calculated using this formula:

time for a phase = x 720 minutes

For example, if 109 cells were counted in metaphase and 980 total cells were counted, then

109

980

x 720 minutes = 80 minutes

1. Using your data, calculate the time required for each phase of mitosis and for interphase. Use the total of both areas counted. Assume the total time for mitosis is 720 minutes.
2. Record the times in Table 1.

**Lab. Report**

**I. Purpose:** The purpose of this lab is to \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**II. Hypothesis:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

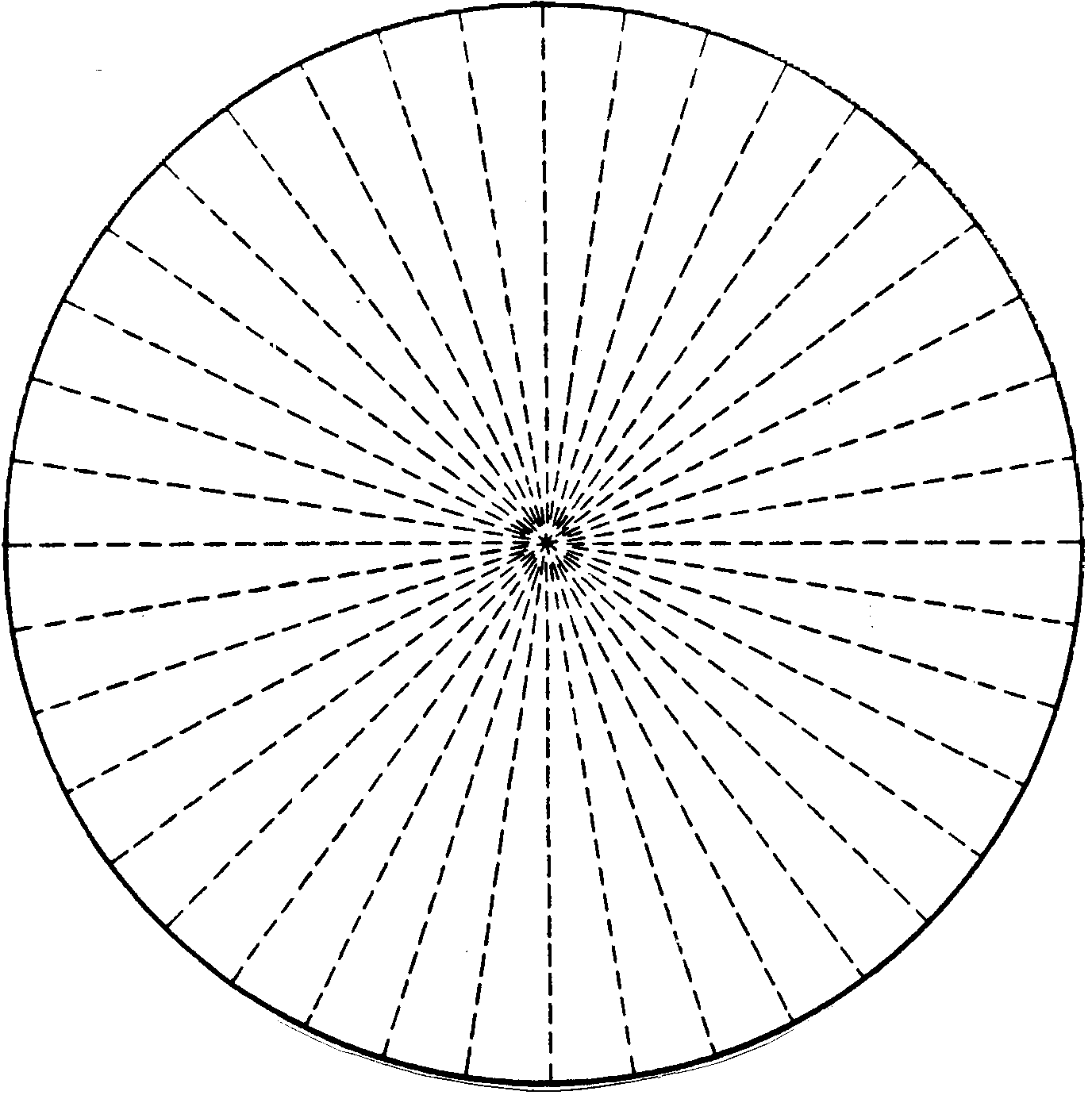
1. **Data Table**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Table 1 – Results of Counting Cells in Each Phase of Mitosis and Interphase** | | | | |
| **Phase** | **1st Area** | **2nd Area** | **Total # of Cells in Each Phase** | **Time in**  **Minutes** |
| Interphase |  |  |  |  |
| Prophase |  |  |  |  |
| Metaphase |  |  |  |  |
| Anaphase |  |  |  |  |
| Telophase |  |  |  |  |
|  |  | Totals |  | 720 |

**IV.** **Graph**

Using your data from Table 1 and the outline below, prepare a pie graph that shows the number of minutes that onion cells spend in each phase of mitosis. The following suggestions may aid you in preparing your graph.

1. Use the “Time In Minutes” column from Table 1 to graph your data.
2. The circle is divided into 18-minute sections. If a phase is not exactly 18 minutes long (or some interval close to a multiple of 18 minutes), approximate the position of the line on the graph.
3. Begin your graph at any section.
4. Color each phase on your graph with a different colored pencil.
5. Identify each phase by coloring the key to correspond to the color on your graph.



|  |  |
| --- | --- |
| Key: |  |
|  |  |
|  | = Interphase |
|  |  |
|  | = Prophase |
|  |  |
|  | = metaphase |
|  |  |
|  | = Anaphase |
|  |  |
|  | =Telophase |

1. **Analysis Questions**
2. Which phase requires the longest time for completion? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. What important processes are occurring in the nucleus and the cell during the longest phase? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Why do you think so much time was spent in this phase? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Which phase requires the *next* longest time for completion? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. Which phase requires the shortest time for completion? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Table 2** shows average times required for normal and cancerous chicken-stomach cells to complete mitosis. Refer to Table 2 to answer questions 5-10.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Table 2 - Time for Mitosis of Normal and Cancerous Chicken-Stomach Cells (in minutes)** | | | | | |
|  | **Interphase** | **Prophase** | **Metaphase** | **Anaphase** | **Telophase** |
| Normal chicken | 540 | 60 | 10 | 3 | 12 |
| Cancerous chicken | 380 | 45 | 10 | 3 | 10 |

1. In normal chicken cells, which phase requires the longest time for completion? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. In normal chicken cells, which phase requires the next longest time for completion? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

How do your answers to questions 5 & 6 compare to your answers to questions 1 & 3? Explain. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. What is the total time needed for a normal chicken-stomach cell to complete a cycle? Show your work. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. What is the total time needed for a cancerous chicken-stomach cell to complete a cycle? Show your work. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. How do cancer cells differ from normal cells in time spent for each phase? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Table 3** shows the length of time needed for mitosis to occur in normal cells of two different organisms. Refer to Table 3 to answer questions 11-12.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Table 3 – Time Needed for Mitosis (in minutes)** | | | | | |
|  | **Prophase** | **Metaphase** | **Anaphase** | **Telophase** | **Total** |
| Salamander kidney cells | 60 | 50 | 6 | 70 | 186 |
| Pea root cells | 80 | 40 | 4 | 12 | 136 |

1. Which cells, salamander kidney or pea root, show time needed to complete mitosis most like the data you recorded in Table 1? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. Why might the times required to complete mitosis be similar for the organism you chose in question 10 and the organism studied in Part A (onion root tip)? Explain. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. **Conclusion**

* Begin your conclusion by restating the purpose of the lab in past tense.
* Then, write a paragraph describing the cell cycle – in other words, describe what happens during interphase and each phase of mitosis and cytokinesis.
* Next, look back at your hypothesis and explain whether your hypothesis was supported or refuted.
* Finally, write a paragraph summarizing your results from this lab. This should include a ranking of the amount of time spent in each phase. You should also compare the amount of time spent for mitosis between normal and cancerous cells.
* Finish your conclusion by listing several sources of error and how they could be corrected.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Biology I (Honors) Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Article: Understanding Cancer Period: \_\_\_\_\_ Date: \_\_\_/\_\_\_/\_\_\_

**Objective 9:** Analyze how cells grow and reproduce in terms of interphase, mitosis, and cytokinesis.

1. Define the following vocabulary words used throughout the reading article:
   1. Cancer—
   2. Proliferation—
   3. Tumor—
   4. In Situ Cancer—
   5. Invasive Cancer—
   6. Malignant—
   7. Hyperplasia—
   8. Karkinoma—
   9. Indigenous Cells—
   10. Monoclonal—
2. Briefly describe the stages of tumor development:
3. How are mitosis and cancer related?
4. What causes cells to become cancerous?
5. Describe at least 3 differences between normal and cancerous cells.

**1.**

**2.**

**3.**

1. What is the difference between a lifetime risk and a relative risk in terms of cancer?
2. The NCI (National Cancer Institute) estimates overall annual costs for cancer at about $107 billion in 1999. How do you think the costs have changed in the past 9 years? Why?
3. New developments in cancer research are revealed on a daily basis. Describe your understanding of some of these developments and how they may impact your future.
4. What are two questions you had in response to the article?
5. Summarize the article in one concise paragraph. Remember to use your own words!

# Understanding Cancer

In simple terms, **cancer** is a group of more than 100 diseases that develop across time and involve the uncontrolled division of the body's cells. Although cancer can develop in virtually any of the body's tissues, and each type of cancer has its unique features, the basic processes that produce cancer are quite similar in all forms of the disease.

Cancer begins when a cell breaks free from the normal restraints on cell division and begins to follow its own agenda for proliferation (Figure 3). All of the cells produced by division of this first, ancestral cell and its progeny also display inappropriate proliferation. A **tumor**, or mass of cells, formed of these abnormal cells may remain within the tissue in which it originated (a condition called in situ cancer), or it may begin to invade nearby tissues (a condition called invasive cancer). An invasive tumor is said to be **malignant**, and cells shed into the blood or lymph from a malignant tumor are likely to establish new tumors (**metastases)** throughout the body. Tumors threaten an individual's life when their growth disrupts the tissues and organs needed for survival.

|  |
| --- |
| figure 3  **Figure 3** - The stages of tumor development. A malignant tumor develops across time, as shown in this diagram.  **a.** The tumor begins to develop when a cell experiences a mutation that makes the cell more likely to divide than it normally would.  **b.** The altered cell and its descendants grow and divide too often, a condition called hyperplasia. At some point, one of these cells experiences another mutation that further increases its tendency to divide.  **c.** This cell's descendants divide excessively and look abnormal, a condition called dysplasia. As time passes, one of the cells experiences yet another mutation.  **d.** This cell and its descendants are very abnormal in both growth and appearance. If the tumor that has formed from these cells is still contained within its tissue of origin, it is called in situ cancer. In situ cancer may remain contained indefinitely.  **e.** If some cells experience additional mutations that allow the tumor to invade neighboring tissues and shed cells into the blood or lymph, the tumor is said to be malignant. The escaped cells may establish new tumors (metastases) at other locations in the body. |

***What happens to cause a cell to become cancerous?***

Scientists know that cancer arises from cells that begin to proliferate uncontrollably within the body, and they know that chemicals, radiation, and viruses could trigger this change. Cancer is a disease of molecules and genes, and scientists even know many of the molecules and genes involved.

## Unraveling the Mystery of Cancer

People likely have wondered about the cause of cancer for centuries. Its name derives from an observation by Hippocrates more than 2,300 years ago that the long, distended veins that radiate out from some breast tumors look like the limbs of a crab. From that observation came the term *karkinoma* in Greek, and later, *cancer* in Latin.

***Clues from Epidemiology.*** One of the most important early observations that people made about cancer was that its incidence varies between different populations. For example, in 1775, an extraordinarily high incidence of scrotal cancer was described among men who worked as chimney sweeps as boys. In the mid-1800s, lung cancer was observed at alarmingly high rates among pitchblende miners in Germany. And by the end of the 19th century, using snuff and cigars was thought by some physicians to be closely associated with cancers of the mouth and throat.

These observations and others suggested that the origin or causes of cancer may lie outside the body and, more important, that cancer could be linked to identifiable and even preventable causes. These ideas led to a widespread search for agents that might cause cancer. One early notion, prompted by the discovery that bacteria cause a variety of important human diseases, was that cancer is an infectious disease. Another idea was that cancer arises from the chronic irritation of tissues. This view received strong support with the discovery of X-rays in 1895 and the observation that exposure to this form of radiation could induce localized tissue damage, which could lead in turn to the development of cancer. A conflicting view, prompted by the observation that cancer sometimes seems to run in families, was that cancer is hereditary.

***Clues from Cell Biology.***

Cell biologists studied the characteristics of cancer cells, through observations in the laboratory and by inferences from their appearance in the whole organism. One such understanding is that cancer cells are indigenous cells—abnormal cells that arise from the body's normal tissues. Furthermore, virtually all malignant tumors are monoclonal in origin or derived from a single ancestral cell that somehow underwent conversion from a normal to a cancerous state.

A second critical understanding that emerged from studying the biology of cancer cells is that these cells show a wide range of important differences from normal cells. For example, cancer cells are genetically unstable and prone to rearrangements, duplications, and deletions of their chromosomes that cause their progeny to display unusual traits. Thus, although a tumor as a whole is monoclonal in origin, it may contain a large number of cells with diverse characteristics.

Cancerous cells also look and act differently from normal cells. In most normal cells, the nucleus is only about one-fifth the size of the cell; in cancerous cells, the nucleus may occupy most of the cell's volume. Tumor cells also often lack the differentiated traits of the normal cell from which they arose. Whereas normal secretory cells produce and release mucus, cancers derived from these cells may have lost this characteristic. Likewise, epithelial cells usually contain large amounts of keratin, but the cells that make up skin cancer may no longer accumulate this protein in their cytoplasms.

The key difference between normal and cancerous cells, however, is that cancer cells have lost the restraints on growth that characterize normal cells. Significantly, a large number of cells in a tumor are engaged in mitosis, whereas mitosis is a relatively rare event in most normal tissues. Cancer cells also do not cooperate with other cells in their environment. They often proliferate indefinitely in tissue culture. The ability to divide for an apparently unlimited number of generations is another important characteristic of the cancerous state, allowing a tumor composed of such cells to grow without the constraints that normally limit cell growth.

## The Human Face of Cancer

For most Americans, the real issues associated with cancer are personal. More than 8 million Americans alive today have a history of cancer (National Cancer Institute, 1998; Rennie, 1996). In fact, cancer is the second leading cause of death in the United States, exceeded only by heart disease.

Everyone is at some risk of developing cancer. Cancer researchers use the term **lifetime risk** to indicate the probability that a person will develop cancer over the course of a lifetime. In the United States, men have a 1 in 2 lifetime risk of developing cancer, and women have a 1 in 3 risk.

**Relative risk** compares the risk of developing cancer between persons with a certain exposure or characteristic and persons who do not have this exposure or characteristic. For example, a person who smokes has a 10-to-20-fold-higher relative risk of developing lung cancer compared with a person who does not smoke. This means that a smoker is 10 to 20 times more likely to develop lung cancer than a nonsmoker.

Hereditary factors also contribute to the development of cancer by dictating a person's general physiological traits. For example, a person with fair skin is more susceptible to the development of skin cancer than a person with a darker complexion. Likewise, a person whose body metabolizes and eliminates a particular carcinogen relatively inefficiently is more likely to develop types of cancer associated with that carcinogen than a person who has more efficient forms of the genes involved in that particular metabolic process.

## Cancer and Society

But what does this mean for society? The financial costs of cancer loom large, not only for the individual but also for the community. The NCI estimates overall annual costs for cancer at about $107 billion. This cost includes $37 billion for direct medical costs, $11 billion for morbidity costs (cost of lost productivity), and $59 billion for mortality costs. Interestingly, treatment for breast, lung, and prostate cancers account for more than one-half of the direct medical costs.

Although early detection and successful treatment can reduce cancer deaths, the most desirable way to reduce them is prevention. In fact, scientists estimate that as many as one-half of the deaths from cancer in the United States and Europe, two areas with closely tracked cancer rates, could theoretically be prevented.